APPARATUS OF CONVERTING
OCEAN WAVE ENERGY INTO ELECTRIC POWER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to energy conversion and more particularly to an apparatus of converting ocean wave energy into electric power with improved characteristics.

2. Description of Related Art

As known that wave can move up and down or back and forth in a curving motion. Ocean wave power plant is thus developed by placing a power generator unit on a float in the sea. Electricity is generated by the generator by absorbing energy of waves as waves continuously move therethrough. Conventionally, a hydraulic turbine or gas turbine is installed in a ocean wave power generator. A turbine is a rotary device per se. This gives an impression to people that electricity can be generated only by a turbine or the like. The prior turbine based electricity generation suffered from several disadvantages. For example, energy of waves is converted into high pressure liquid or air which in turn impinges vanes of a hydraulic turbine or gas turbine for rotating the same. Finally, the generator is driven by the hydraulic turbine or gas turbine for generating electricity. Such multiple energy conversions can consume energy significantly, i.e., lower energy conversion efficiency. Further, it can complicate the electric generation system, resulting in an increase in the installation and maintenance costs. Furthermore, the turbine can be eliminated for simplifying construction as viewed by the present inventor.

Other prior art have been found in a search as below. For example, U.S. Pat. No. 4,178,517 disclosed a process for conversion of ocean wave energy into electric power and apparatus in which wave motion is used to vary the

pressure of hydrogen gas in one of the cavities of a two-cavity chamber. The resulting imbalance of pressures in the cavities is relieved by conduction of hydrogen ions through a protonic conductor separating the cavities, and by conduction of electrons through an external circuit, enabling hydrogen gas to be formed on the low-pressure side of the chamber. The conduction of electrons constitutes an electric current. Also, U.S. Pat. No. 5,136,173 disclosed an ocean wave energy conversion system in which electricity is generated by flowing sea water through a magnet hydrodynamic electric generator. Both prior arts have the generator installed under sea level. This is not desirable as viewed by the present inventor. Moreover, the present invention is still distinguished from both prior art even they also do not employ the turbine as the present invention. Thus, continuing improvements in the exploitation of the conversion of ocean wave energy into electric power are constantly being sought.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an apparatus of converting ocean wave energy into electric power, comprising a floating section comprising a float adapted to ride on the surface of the ocean in reciprocal vertical motion in response to ocean wave front action, and a lever adapted to ride on the surface of the ocean, the lever having one end coupled to the float; and a fixed section mounted on a seacoast, ship, or production platform and comprising a fulcrum for pivotably supporting the lever, a magnet coupled to the other end of the lever, a plurality of parallel cores together with the magnet for forming a magnetic circuit, a plurality of parallel electric coils each wound on the corresponding core, resilient means adjacent the magnet interconnected the lever and the magnet, a plurality of barriers each disposed between two adjacent ones of the cores, and support means, whereby an upward motion of the float caused by the impact of waves will move the magnet downward by the

leverage of the lever and compress the resilient means, a downward motion of the float will move the magnet upward by the leverage of the lever and expand the resilient means, and repeating of the upward and the downward movements of the magnet will induce a voltage in the electric coils.

It is another object of the present invention to provide an apparatus of converting ocean wave energy into electric power, comprising support means mounted on a fixed section mounted on a dam, seacoast, or breakwater, an intermediate vibration member having a lower portion submerged in the seawater, the vibration member including a driving shaft rotatably coupled to the support means, a magnet on top of the vibration member, a plurality of parallel cores together with the magnet for forming a magnetic circuit, a plurality of parallel electric coils each wound on the corresponding core, left and right resilient means adjacent the vibration member and coupled to the intermediate vibration member, and a plurality of barriers each disposed between two adjacent ones of the cores, whereby a vibration of the vibration member caused by the impact of waves will compress the left resilient means and expand the right resilient means via the driving shaft so as to move the magnet, and repeating of the movement of the magnet will induce a voltage in the electric coils.

The above and other objects, features and advantages of the present invention will become apparent from the following detailed description taken with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 schematically depicts a top plan view of a first preferred embodiment of ocean wave energy conversion apparatus according to the invention;

FIG. 2 schematically depicts a front view of the apparatus shown in FIG. 1;

FIG. 3 schematically depicts a front view of a second preferred embodiment

of ocean wave energy conversion apparatus according to the invention;

FIG. 4 schematically depicts a side plan view of the apparatus shown in FIG. 3; and

FIG. 5 schematically depicts a top plan view of electrically connecting an external power source to the coil for providing additional magnetic field according to the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 1 and 2, there is shown an apparatus constructed in accordance with a first preferred embodiment of the invention. The apparatus comprises a float 4 adapted to ride on the surface of the ocean in reciprocal vertical motion in response to ocean wave front action, and a lever 5 also adapted to ride on the surface of the ocean, the lever 5 having one end coupled to the float 4. On a seacoast, ship, or production platform, the apparatus further comprises a fulcrum 6 for pivotably supporting the lever 5, a magnet 1 coupled to the other end of the lever 5, a plurality of (three) parallel cores 2 together with the magnet 1 for forming a magnetic circuit, a plurality of (three) parallel electric coils 3 each wound on the core 2, a spring 7 adjacent the magnet 1 interconnected the lever 5 and the magnet 1, a plurality of barriers 8 each disposed between two adjacent ones of the cores 2, and a support mechanism (not shown).

The characteristics of the first preferred embodiment are detailed below. The conventional hydraulic turbine or gas turbine is not provided. In operation, an upward motion of the float 4 caused by the impact of waves will cause the magnet 1 to move downward by the leverage of the lever 5 and compress the spring 7 simultaneously. Further, a downward motion of the float 4 will cause the magnet 1 to move upward by the leverage of the lever 5 and expand the spring 7 simultaneously. Such reciprocal motion of the magnet 1 will induce a voltage

(i.e., current) in the coils 3 since the coils 3 cut lines of magnetic flux (i.e., magnetic flux change). As a result, electricity is generated by ocean wave energy.

Referring to FIGS. 3 and 4, there is shown an apparatus constructed in accordance with a second preferred embodiment of the invention. The apparatus comprises a support mechanism 9 mounted on seacoast, dam, or breakwater, a vibration member 10 having a lower portion submerged in the seawater, the vibration member 10 including a driving shaft 11 rotatably coupled to the support mechanism 9, a magnet 1 on top of the vibration member 10, a plurality of (three) parallel cores 2 on top of the support mechanism 9, the cores 2 together with the magnet 1 for forming a magnetic circuit, a plurality of (three) parallel electric coils 3 wound on the cores 2, a left spring 71 and a right spring 72 both adjacent the vibration member 10 and coupled to the intermediate vibration member 10, and a plurality of barriers 8 each disposed between two adjacent ones of the cores 2.

The characteristics of the second preferred embodiment are detailed below. Also, the conventional hydraulic turbine or gas turbine is not provided. In operation, a vibration of the vibration member 10 caused by the impact of waves will compress the left spring 71 and expand the right spring 72 simultaneously via the transmission of the driving shaft 11. And in turn, the magnet 1 moves. Such reciprocal motion of the magnet 1 will induce a voltage (i.e., current) in the coils 3 since the coils 3 cut lines of magnetic flux (i.e., magnetic flux change). As a result, electricity is generated by ocean wave energy.

According to Faraday's law of induction, induced voltage is proportional to the number of coil turns. However, electrical resistance is also proportional to the number of coil turns. Hence, it is preferably to increase the diameter of coil

for significantly reducing electrical resistance as the number of coil turns increases. Moreover, induced voltage is also proportional to magnetic flux change in the coil. Also, magnetic flux is proportional to magnetic intensity, cross-section of magnetic circuit, and magnetic permeability of magnetic circuit. Thus, increase of magnetic permeability, cross-section of magnetic circuit, and magnetic inductivity of magnetic circuit can increase induced voltage. In addition, an increase of moving speed of the magnet can increase magnetic flux change.

In the first preferred embodiment, a moving distance of the float 4 will be equal to that of the magnet 1 in one upward or downward movement if there is no provision of the lever 5. Fortunately as devised by the invention, a moving distance of the magnet 1 is larger than that of the float 4 in one upward or downward movement since the distance from the magnet 1 to the fulcrum 6 is larger than the distance from the float 4 to the fulcrum 6 as taught by leverage. Accordingly, magnetic flux change in the magnetic circuit can be increased significantly. Likewise, in the second preferred embodiment, a distance from the driving shaft 11 to the magnet 1 at top of the vibration member 10 is larger than a distance from the driving shaft 11 to a bottom of the vibration member 10 as devised by the invention. This can also increase a moving speed of the magnet 1 and thus increase magnetic flux change in the magnetic circuit.

Additionally, induced voltage will be smaller if the electric coils 3 are not wound on the cores 2 since magnetic permeability of air is very small. Fortunately, induced voltage will be very large since the core 2 has a high magnetic permeability as embodied in each of the first and second preferred embodiments. In a case that there is only one pair of magnet 1 and core 2, no line of magnetic flux will be cut when the magnet 1 leaves the effective magnetic area of the core 2. That is, magnetic flux is not changed and thus

there is no induced voltage. This is not desirable. Thus, as stated above, a plurality of parallel sets of cores 2 and electric coils 3 are provided by the invention in which each of the plurality of barriers 8 is disposed between two adjacent cores 2. Hence, magnetic flux change can be increased significantly. Preferably, a cross-section of the magnet 1 is about the same as that of the core 2 so as to obtain a maximum magnetic flux change in operation.

A small voltage will be induced if the magnet 1 is a permanent magnet due to smaller magnetic intensity. Fortunately, referring to FIG. 5, as embodied by the invention the magnet 1 is formed of the same ferromagnetic material as the core 2 with magnetic field around each of the cores 2 is generated by another electric coil 31 wound thereon. The coil 31 is in turn electrically coupled to an external power source 12. As a result, induced voltage is greatly increased due to larger magnetic flux change.

As to the problem of unstable electricity generated by ocean wave energy conversion process as experienced in the prior art, it can be solved by many commercially available, advanced power electronic devices. This is similar to wind turbine electricity production.

While the invention herein disclosed has been described by means of specific embodiments, numerous modifications and variations could be made thereto by those skilled in the art without departing from the scope and spirit of the invention set forth in the claims.